

HL-LHC baseline

Lucio Rossi - CERN



High
Luminosity
LHC



LS2 DAYS

29-30 SEPTEMBER 2015

<http://indico.cern.ch/event/436424/>

Main Goals of HL-LHC



The main objective of HiLumi LHC Design Study is to determine a hardware configuration and a set of beam parameters that will allow the LHC to reach the following targets:

A peak luminosity of **$5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ with levelling**, allowing:

An integrated luminosity of **250 fb^{-1} per year**, enabling the goal of **3000 fb^{-1}** .

This luminosity is more than ten times the luminosity reach of the first 10 years of the LHC lifetime.

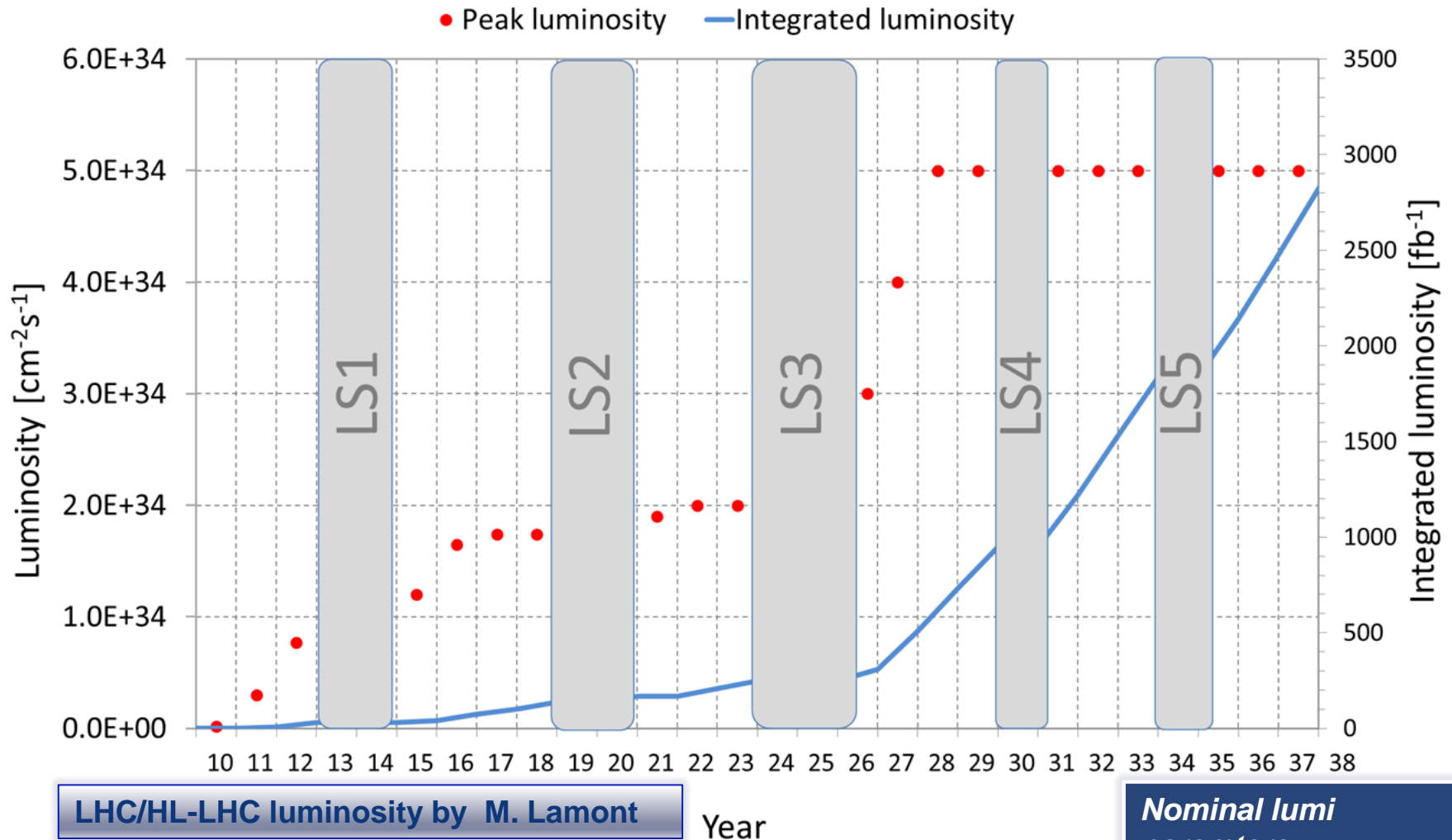
Concept of ultimate performance (Oct.2013, ECFA & RLIUP) defined:

$$L_{\text{peak}} \cong 7.5 \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1} \text{ and Int. L} \sim 4000 \text{ fb}^{-1}$$

LHC should not be the limit, would Physics require more...

Nominal upgrade parameters

3000 fb⁻¹ would be reached in 2038



Nominal lumi paramters

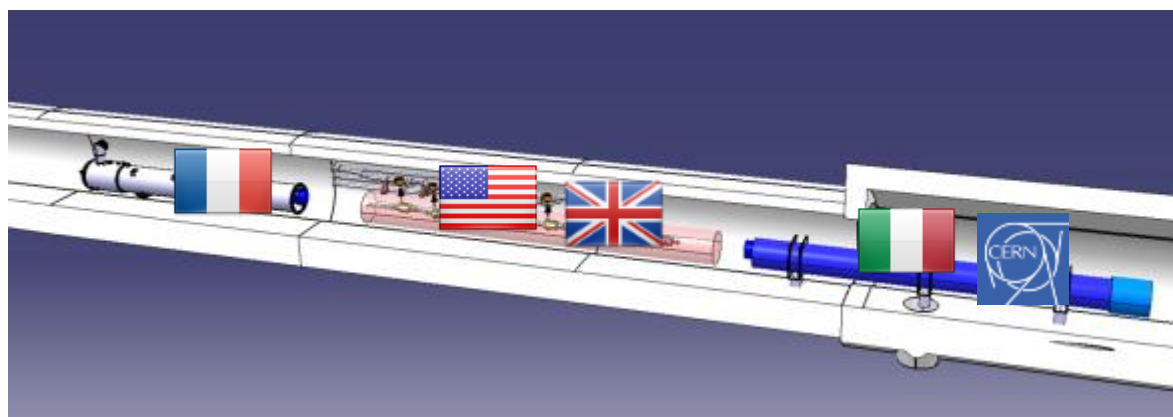
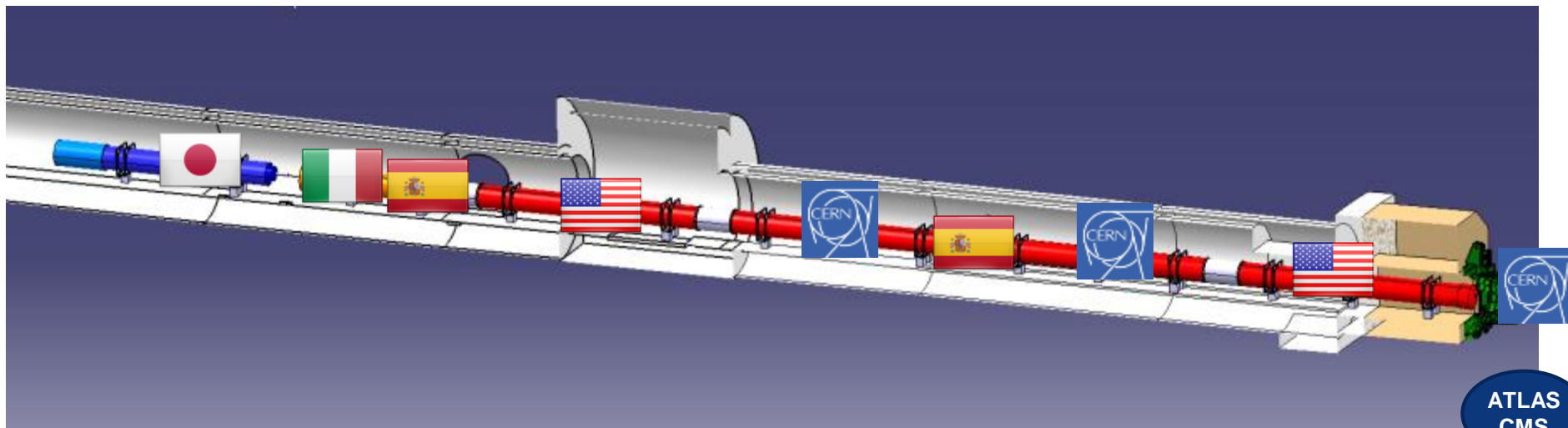
- $L = 5 \cdot 10^{34} \text{ cm}^2\text{s}^{-1}$
- $\text{Int. } L = 3000 \text{ fb}^{-1}$

LHC/HL-LHC luminosity by M. Lamont

Year

Parameter	Nominal LHC (design report)	HL-LHC 25ns (standard)	HL-LHC 25ns (BCMS) ⁹	HL-LHC 8b+4e ¹²
Beam energy in collision [TeV]	7	7	7	7
N_b	1.15E+11	2.2E+11	2.2E+11	2.3E+11
n_b	2808	2748	2604	1968
Number of collisions in IP1 and IP5 ¹	2808	<u>2736</u>	<u>2592</u>	1960
N_{tot}	3.2E+14	6.0E+14	5.7E+14	4.5E+14
beam current [A]	0.58	<u>1.09</u>	1.03	0.82
x-ing angle [μ rad]	285	590	590	554 ¹⁰
beam separation [σ] ¹¹	9.4	12.5	12.5	12.5 ¹⁰
β^* [m]	0.55	<u>0.15</u>	0.15	0.15
ϵ_n [μ m]	3.75	2.50	2.50	2.20
ϵ_L [eVs]	2.50	2.50	2.50	2.50
r.m.s. energy spread	1.13E-04	1.13E-04	1.13E-04	1.13E-04
r.m.s. bunch length [m]	7.55E-02	7.55E-02	7.55E-02	7.55E-02
IBS horizontal [h]	80 -> 106	18.5	18.5	13.1
IBS longitudinal [h]	61 -> 60	20.4	20.4	17.6
Piwinski parameter	0.65	3.14	3.14	3.14
Total loss factor R0 without crab-cavity	0.836	0.305	0.305	0.304
Total loss factor R1 with crab-cavity	(0.981)	0.829	0.829	0.828
beam-beam / IP without Crab Cavity	3.1E-03	3.3E-03	3.3E-03	3.9E-03
beam-beam / IP with Crab cavity	3.8E-03	1.1E-02	1.1E-02	1.3E-02
Peak Luminosity without crab-cavity [$\text{cm}^{-2} \text{s}^{-1}$]	1.00E+34	7.18E+34	6.80E+34	6.38E+34
Virtual Luminosity with crab-cavity: $L_{peak} \cdot R1/R0$ [$\text{cm}^{-2} \text{s}^{-1}$]	(1.18E+34)	<u>19.54E+34</u>	18.52E+34	17.40E+34
Events / crossing without levelling and without crab-cavity	27	198	198	246
Levelled Luminosity [$\text{cm}^{-2} \text{s}^{-1}$]	-	5.00E+34 ⁵	5.00E+34	3.63E+34
Events / crossing (with leveling and crab-cavities for HL-LHC) ⁸	27	138	146	140
Peak line density of pile up event [event/mm] (max over stable beams)	0.21	1.25	1.31	1.28
Leveling time [h] (assuming no emittance growth) ⁸	-	8.3	7.6	9.5
Number of collisions in IP2/IP8	2808	2452/2524 ⁷	2288/2396	1163/1868
N_b at LHC injection ²	1.20E+11	2.30E+11	2.30E+11	2.40E+11
n_b / injection	288	288	288	224
N_{tot} / injection	3.46E+13	6.62E+13	6.62E+13	5.40E13
ϵ_n at SPS extraction [μ m] ³	3.40	2.00	< 2.00 ⁶	1.70

Contributing IR in IP1 and IP5 counting on many In-kind contributions



Q1-Q3 : R&D, Design, Prototypes and in-kind **USA**

D1 : R&D, Design, Prototypes and in-kind **JP**

MCBX : Design and Prototype **ES**

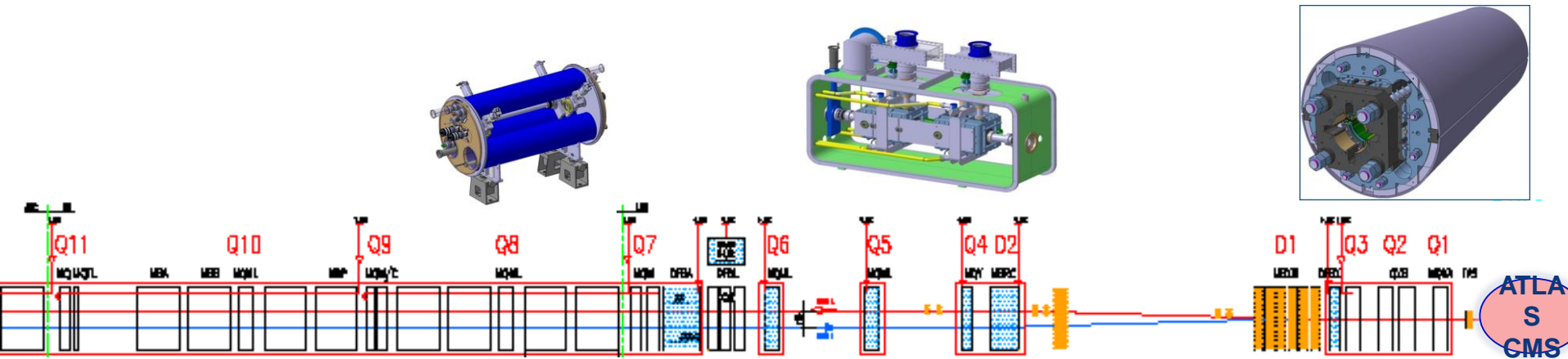
HO Correctors: Design and Prototypes **IT**

Q4 : Design and Prototype **FR**

CC : R&D, Design and in-kind **USA**

CC : R&D and Design **UK**

The largest accelerator in construction



Dispersion Suppressor (DS)

Modifications

1. In IP2: new DS collimation
2. In IP7 new DS collimation with 11 T

Cryogenics, Protection, Interface, Vacuum, Diagnostics, Inj/Extr... extension of infrastr.

Matching Section (MS)

Complete change and new lay-out

1. TAN
2. D2
3. CC
4. Q4
5. All correctors
6. Q5 (present Q4)
7. New Q5 in P6
8. New collimators

Interaction Region (ITR)

Complete change and new lay-out

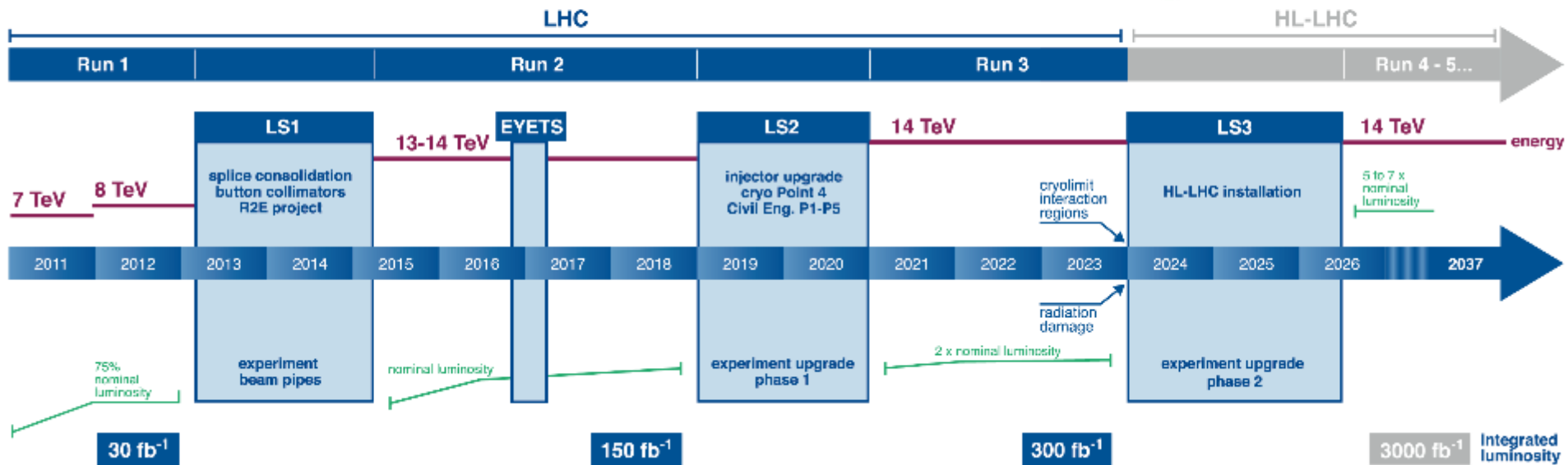
1. TAS
2. Q1-Q2-Q3
3. D1
4. All correctors
5. Heavy shielding (W)

> 1.2 km of LHC

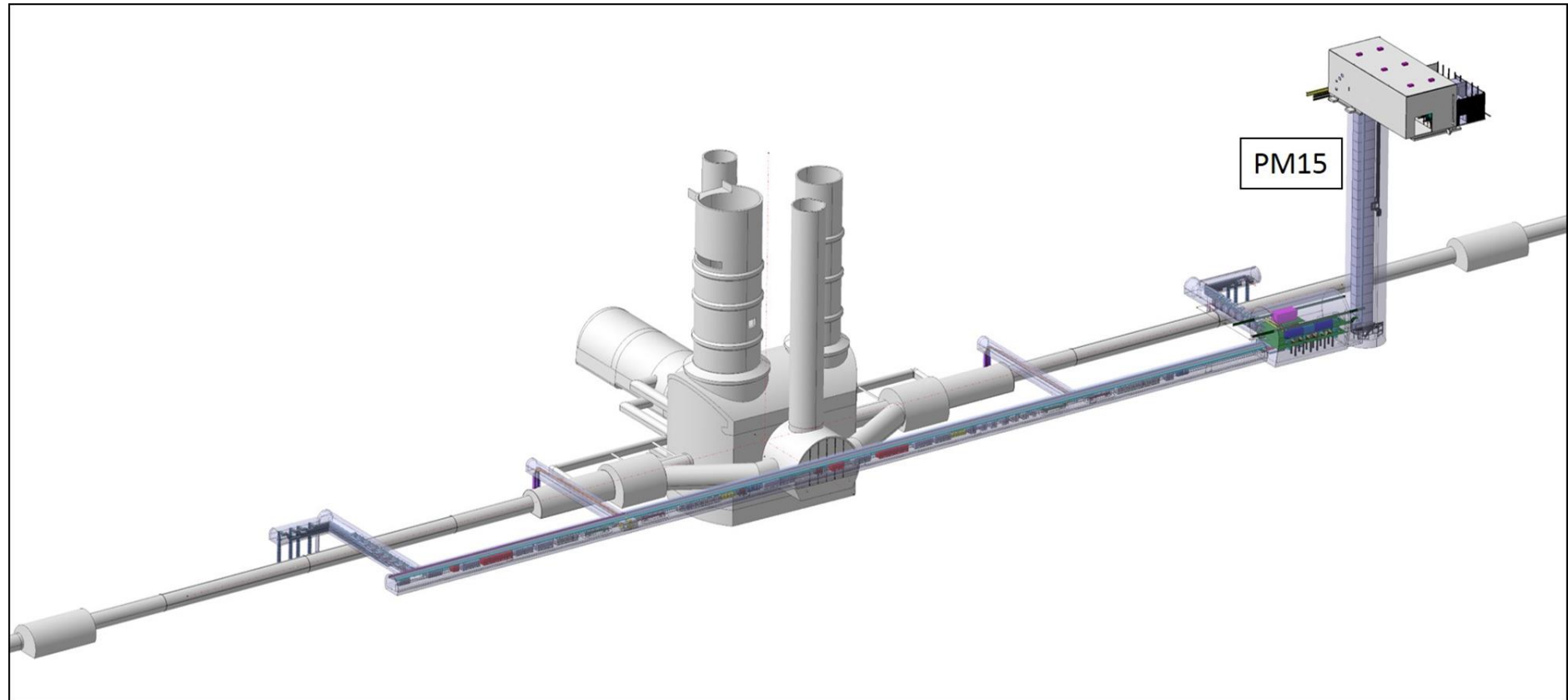
But very little for LS2...



LHC / HL-LHC Plan



For HL-LHC LS2 will be the period of D(TH)RILLING!



However we will not be idle...



- Before LS2:

- SM18 upgrade – critical for HL-LHC – will be going on (use of CERN services)
- Test of CC in SPS (2016 EYETS for infrastructure and 2017 YETS for installation of a cryomodule).
- New collimators with LRBB compensating wires for test
- Preparation C.E.

- During LS2:

- New Q5 in LSS6 for ATS optics, more installation of CC in SPS for test
- New DS collimator in Left and Right of P2. for ions, with by-pass
- Modification of Cryo in P4 for testing SCRF cavities separately from Arc Magnets
- Coating –in situ- of ITR P2 and P8 for fighting e-clouds! (minimizing radiation dose to people)
- Installation of other equipment as prototypes or test before large installation in LS3

The uncertainty: 11 T

- After C&S Review of March 2015, revision of needs for 11 T in IR2 for ions.
 - Collimator with Cold2Warm2Cold by-pass can be put in the connection cryostat
 - However, pending a quench test with ions (not done in Run1) and pending a quench test with prpton at high energy for P7 (where also there si uncertainty if the 11 T are need before LS3 or not).
- We ask to keep open the possibilty to install 2 units of 11 T around P2 or P7 **in case of need** in the second part of LS2.
- The issue will be defined at Chamonix 2016 or in Spring 2016 at latest.



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More material and plan in Paula's presentation!

Thanks